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INSTRUCTIONS FOR

ELECTRONIC VOLTMETER

MODEL 314

BALLANTINE LABORATORIES, INC.
BOONTON, NEW JERSEY

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CONTENTS

SPECIFICATIONS

BALLANTINE MODEL 314 ELECTRONIC VOLTMETER

Frequency Range

15 cps to 6 megacycles

Voltage Range

1 millivolt to 1000 volts with probe
100 microvolts to 1 millivolt without probe

Accuracy

3% from 15 cps to 3 megacycles; 5% above 3 megacycles

Power Supply

110-120 volts, 50-60 cps, 40 watts. Operation on line voltages as low as 105 or as high as 125 volts will not affect accuracy by more than one per cent.

Input Impedance

11.1 meg shunted by 6 $\mu\mu$f with probe
1.11 meg shunted by 25 $\mu\mu$f without probe

Scales

Logarithmic voltage scale (illuminated) reading from 1 to 10;
Auxiliary scale in decibels from 0 to 20.

Amplifier Characteristics

Maximum voltage gain of 60 db, adjustable by means of range switch to 40 or 20 db. Output impedance 500 ohms. Maximum output voltage 1 volt.
Flat within:

½ db from 100 cps to 3 megacycles
1 db from 50 cps to 6 megacycles

Tubes

Six Type 6AK5; two Type OA2; one Type 6X4.
All tubes supplied.

Dimensions

6¾" wide, 6" high, 10⅞" long;
Maximum extension of probe from instrument 36".

Weight

11 pounds

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BALLANTINE MODEL 314
ELECTRONIC VOLTMETER

GENERAL — This instrument is designed to measure sinusoidal voltages from 100 microvolts to 1000 volts over a frequency range from 15 cps to 6 megacycles. It operates from a 110-120 volt 60 cps power supply.

The voltage range of the instrument when used with the probe is 1 millivolt to 1000 volts and its input impedance is 11.1 megohms shunted by 6 $\mu\mu f$. Since the probe has an attentuation ratio of 10 to 1, the sensitivity of the instrument when used without the probe is increased to 100 microvolts and the input impedance is then 1.11 megohms shunted by 25 $\mu\mu$f. The voltmeter may be used without the probe to measure in the range of 1 millivolt to 100 volts but at reduced accuracy in respect to measurements made in the same range with the probe.

The accuracy of the instrument for all ranges and at any point on the meter scale is within 3% from 15 cps to 3 megacycles and 5% above 3 megacycles.

By means of a six decade range selector switch the entire voltage range may be read on a single logarithmic voltage scale reading from 1 to 10. **The markings on the range selector switch refer to full scale voltages with the probe connected. If the instrument is used without the probe the full scale voltage for any particular range for which the selector switch is set will be one-tenth of that marked on the switch.**

The indicating meter also has a uniform decibel scale numbered from 0 to 20 decibels. The zero of the decibel scale is arbitrarily arranged for maximum usefulness so as to correspond to 1 on the voltage scale. This facilitates the use of the scale for the measurement of power levels with various zero references as outlined on page 5.

A coaxial AMPLIFIER OUTPUT socket permits the amplifier section of the voltmeter (probe not used) to be used as a flat pre-amplifier with gains of 20, 40, and 60 db depending on the setting of the range switch.

GENERAL CIRCUIT DESCRIPTION — The voltmeter employs a high impedance resistance-capacitance probe, a resistance-capacitance attenuator, two negative feedback amplifier units, followed by a full-wave rectifier, and a logarithmic indicating meter responding to the average values of the voltage wave but calibrated in rms values of a sinusoidal wave. The second of the two amplifier units incorporates the rectifier in its feedback loop thereby linearizing the rectifier characteristic. Each of the amplifier units has sufficient feedback to render the indications of the instrument substantially independent of changes in line voltage, tubes and other cirucit components. For more details refer to the attached circuit diagram.

OPERATION — The voltmeter is supplied with tubes and is ready to operate as received. It is necessary only to plug the line cord into the specified ac power source and to turn on the switch marked ON-OFF. The illuminating lamps incorporated in the indicating meter serve as pilot lights to indicate when the power is on.

The probe ground terminal is connected to the case of the instrument and therefore, whenever possible, it should be connected directly to the ground of the circuit in which a voltage is being measured.

USE OF THE PROBE — When using the voltmeter with the probe make certain that the probe has the same serial number as the voltmeter. Do not substitute any other probe or probe cord. Also do not attempt to disassemble the probe or alter the length of the cord, since the entire probe assembly including the probe cord is of controlled physical dimensions and has a carefully adjusted rc network, any change in which will affect the accuracy of the instrument.

Connection to the tip of the probe may be made either by touching the needle point of the probe to the conductor whose potential is to be measured or by inserting the conductor between the needle point and the notched portion of the slot in which it normally rests. The needle point applies sufficient pressure against the conductor to hold it in place. If the conductor whose potential is to be measured is located so as to be inaccessible to the probe tip or if it is larger than a #14 awg wire (the largest size conductor which may be inserted between the needle point and its slot without causing the needle

point to spring out too far and assuming a permanent "open set") a wire of about #22 awg and of the shortest possible length should be used to connect the point of the probe to the conductor. (See "SERVICING" for instructions on how to restore needle point to usefulness after it has taken a permanent "open set").

Two forms of probe ground connections are provided, namely the special single action clamp and the alligator clip lead.

The special single action ground clamp is a feature of the Model 314. It assures a low impedance ground connection to a lip on a chassis, for instance, and thereby reduces errors in the measurement of low-level, high-frequency voltages by minimizing spurious potentials arising from stray circulating currents in the ground return impedance. The clamp also provides a convenient means of support for the probe on whatever object it is clamped.

When preparing to use the ground clamp, it is fitted to the pin projecting from the ground lug on the probe, the insertion being from either side of the clamp according to choice of access to the clamp screw. Turning the clamp screw clockwise simultaneously fastens the clamp on both the probe ground lug and on the object inserted between its jaws. When not in use the clamp may be stored on the pin situated on the face of the instrument to the left of the indicating meter.

If the considerations outlined above requiring a ground connection of irreducible minimum impedance are not present, the alligator clip ground lead may be used instead of the ground clamp. The alligator clip lead is used in the customary manner after inserting the plug end in the hole in the ground lug protruding from the side of the probe.

The clamp and clip lead may be used simultaneously. When it is desired to support the probe in position by attaching the clamp to an object electrically disassociated from the system under test, the clip lead may be used in the normal manner to provide the ground return.

AC OVERLOAD CHARACTERISTICS — The amplifier circuits are designed to saturate promptly when the voltage exceeds the full scale indication of the meter, thus protecting the meter movement. This is a considerable advantage over other meters which may be seriously damaged by overloads of magnitudes which the Model 314 will withstand.

The instrument will stand alternating current overloads of at least 100 to 1 on all ranges except the two highest. On these two ranges the maximum safe voltage is 350 volts rms without the probe. With the probe, the overload capacity of the instrument on the 100 and 1000 volt ranges is limited by the dielectric losses in the probe which increase with frequency. Therefore, the application on these two ranges, other than momentarily, of ac voltages much in excess of 1000 volts may damage the probe.

MAXIMUM DC COMPONENT OF INPUT VOLTAGE — An ac voltage superimposed on a dc voltage can be measured either with or without the probe. The maximum dc voltage permissible is 500 volts when the probe is omitted, and 4000 volts less the peak value of the ac voltage under measurement when the probe is used. For dc voltages exceeding the values given, an external blocking capacitor must be used.

EFFECT OF WAVE FORM — The indications of this voltmeter are proportional to the average value of the ac wave under measurement. Since, however, it is primarily intended to measure sinusoidal waves, its calibration is in terms of the rms value of a sinusoidal wave. Since vacuum tube voltmeters of the diode detector type respond to the peak values of a wave, the readings of such meters and the Model 314 will not necessarily agree when harmonics are present. The amount of the discrepancy will depend on the number and magnitude of the harmonics present as well as their phase relationship with respect to the fundamental. In all cases, however, the departure of the readings from true rms values due to the presence of harmonics will be considerably less with an average responding meter, such as the Model 314, than with a peak responding meter. For example, in the case of a third harmonic whose amplitude is 20% of the fundamental the maximum error of a peak responding meter may be as much as 20% whereas the maximum error of an average responding meter will never exceed 6.7%.

Inasmuch as the Model 314 voltmeter responds to the average value of the ac wave, "turn-over" discrepancies occasioned by any lack of symmetry of the wave, such as are experienced in half-wave peak-reading instruments, are eliminated.

MEASUREMENT OF VOLTAGES AT LINE FREQUENCY ON THE 0.01 AND THE 1 VOLT RANGE SETTINGS — Even though the amount of residual hum in the voltmeter is extremely small, it may introduce slight inaccuracies (about 1%) at the lower end of the 0.01 and the 1 volt range

settings when measuring voltages having exactly the same frequency as that of the power supply mains. These inaccuracies may be eliminated by making two measurements, one with the power plug in normal polarity and the other with the power plug reversed. The mean of these readings will represent the true value of the voltage being measured.

USE AS AN AMPLIFIER — By turning the switch marked AMP-METER to the AMP position the Model 314 may be used as a stable, wide-band, high-gain pre-amplifier. The amplifier output socket is designed for a Jones coaxial plug type P-101-3/8", one of which is supplied with the instrument and is attached to the output socket when shipped.

When the range switch is set for the .01 range the gain of the amplifier without the probe is 60 db which gain may be reduced to either 40 or 20 db by setting the range switch to the .1 or the 1 setting respectively. The maximum undistorted output of the amplifier is 1 volt and its output impedance is 500 ohms. When fed into a load having a shunt capacitance of not more than 25 $\mu\mu$f (such as the capacitance of a convenient length of connecting cable) the amplifier will give a response uniform within ½ db from 100 cps to 3 mc and within 1 db from 50 cps to 6 mc. The 3 db points are at approximately 25 cps and 8 mc.

The combined hum and noise level present at the output terminals of the amplifier when set for maximum gain of 60 db is less than 25 millivolts, and, when set for a gain of 40 db, is less than 2.5 millivolts. These levels are 32 db and 52 db respectively down from the maximum undistorted output voltage level of 1 volt.

POWER LEVEL MEASUREMENTS — In view of the many different applications for Ballantine Voltmeters and the prevailing differences in power reference levels, it was felt inadvisable to relate the db scale to any particular level. Accordingly, in the interest of clarity and generality, the 0 of the db scale has been set arbitrarily at 1 on the voltage scale, and 20 db, therefore, corresponds to 10 on the voltage scale.

The most frequently used power reference levels are:

(1) dbm: ———— Level in db referred to 1 milliwatt of power corresponding to 0.775 volts across a pure resistance of 600 ohms.

(2) Zero Level (a):— Level in db referred to 6 milliwatts of power corresponding to 1.897 volts across a pure resistance of 600 ohms.

(3) Zero Level (b):— Level in db referred to 6 milliwatts of power corresponding to 1.732 volts across a pure resistance of 500 ohms.

The following table enables a ready conversion from the db reading on the Ballantine Scale to the actual db power level for any of the various reference levels commonly in use.

MODEL 314 RANGE SWITCH SETTING		DB TO BE ADDED TO OR SUBTRACTED FROM THE DB READING ON THE BALLANTINE DB SCALE IN ORDER TO CONVERT TO THE DESIRED ZERO REFERENCE LEVEL		
Without Probe	With Probe	Zero Level 1mw-600 ohms	Zero Level 6mw-600 ohms	Zero Level 6mw-500 ohms
.01	——	−77.8	−85.6	−84.8
.1	.01	−57.8	−65.6	−64.8
1	.1	−37.8	−45.6	−44.8
10	1	−17.8	−25.6	−24.8
100	10	+ 2.2	− 5.6	− 4.8
1000	100	+22.2	+14.4	+15.2
——	1000	+42.2	+34.4	+35.2

SERVICING — Servicing of this instrument by the user is not recommended except as described below. If trouble develops which cannot be corrected by following the procedures outlined below, it is recommended that the instrument be returned to us for servicing. **Before returning the instrument to us, please describe the trouble to us by letter,** and we shall send shipping instructions.

Scale Range Adjustment — Scale range adjustment is made by means of the red adjusting screw on the case of the indicating meter. When the scale range adjustment is properly made, a voltage which produces a scale reading of 10 will, when reduced by 90% (i.e. in the ratio of 10 to 1), produce a scale reading of 1. Ordinarily no adjustment should be necessary except at very infrequent intervals, but if some discrepancy is noted, an adjustment accurate to approximately 1% may be made as follows:

(1) Turn the instrument "ON" and allow a warm-up period of at least 5 minutes.

(2) Connect to the probe input a stable ac source of about 10 volts of less than 1% distortion and of any convenient frequency from 100 to 10000 cps.

(3) Set the range switch at 10.

(4) Adjust the input voltage to obtain a scale reading of 10.

(5) Set the range switch at 100.

(6) Adjust the red screw on the meter case to obtain a scale reading of 1.

(7) Repeat steps (3) through (6) until no further adjustment is required.

If a source of 10 volts is not available, a 100 volt, a 1 volt, or a 0.1 volt source may be used with range switch settings of 100 and 1000, 1 and 10, or 0.1 and 1 respectively.

Greater accuracy in scale range adjustment may be had by using only one voltage range setting and an external precision 10:1 potential divider which presents to the instrument a source impedance of not more than 10,000 ohms. The procedure would then be as outlined except that level changes would be made with the potential divider instead of the range selector switch.

Calibration Adjustment — Normally, no attention need by given to the matter of calibration as the large amount of feedback in the instrument gives it sufficient inherent stability to maintain the original factory calibration within the accuracy specified. However, to correct errors which might result from the cumulative effects of wide variations in characteristics of replacement tubes from average tubes, a variable control has been provided which allows the calibration to be shifted a small amount. This control is accessible through a hole on the amplifier output side of the chassis, access to which is obtained by lifting the latter from the outer case after unscrewing the four oval head screws (not the Phillips head screws) on the panel.

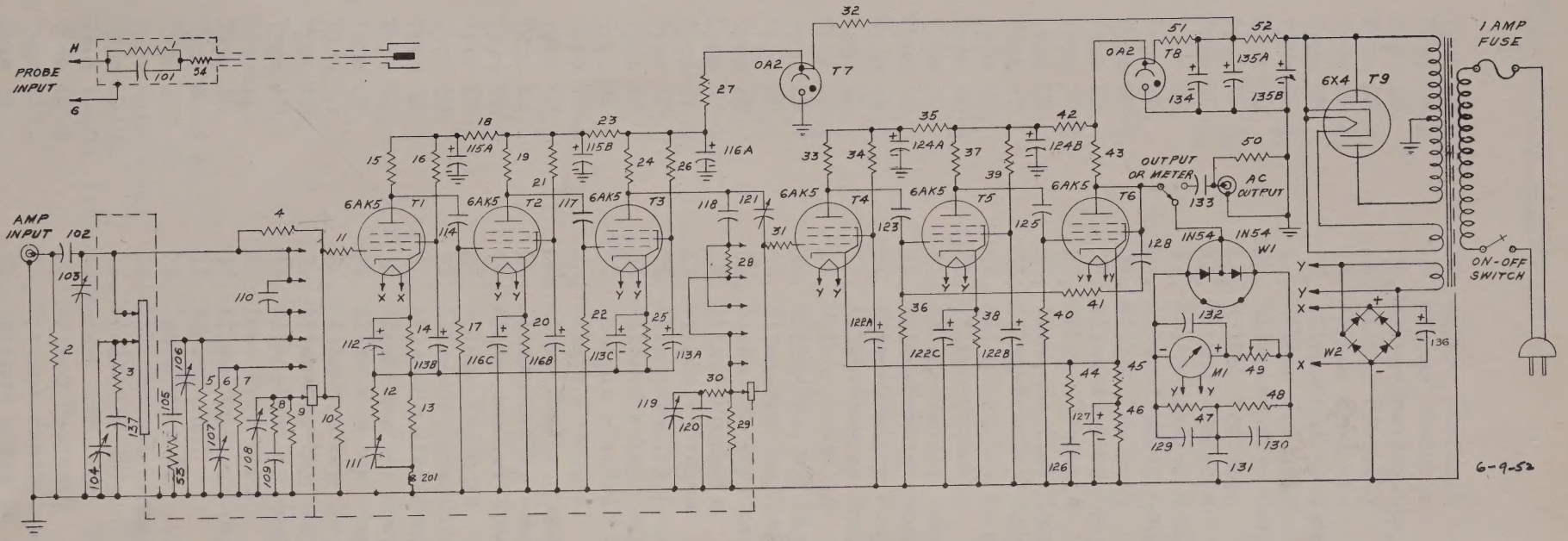
In adjusting the calibration of the instrument the source voltage should be a pure sinusoidal wave of any convenient frequency from 100 to 10,000 cps and the rms indicating voltmeter used as the standard should be accurate to at least 1% at the selected test frequency.

Replacement of Illuminating Lamps — Lamps may be replaced after removing the cover of the indicating meter by unscrewing the two holding screws on the top of the meter cover. Care should be taken to avoid disturbing the setting of the meter spring adjustment when replacing the cover.

Replacement of Fuse — The fuse is a 3 AG, one ampere, cartridge type and is located adjacent to the power cord entrance to the instrument. It unscrews easily without removal of the chassis from the case. A spare fuse is supplied.

Repair of Probe Tip — The self-holding tip has been engineered so that a permanently "open" needle may be easily repaired. Hold the probe in the left hand and grasp the needle point with a pair of smooth-nosed pliers. Set the needle in its slot as it should normally be, and turn the pliers through 180 degrees. This action will revolve the needle in the slot and bring it to a normally closed position. If the needle should become loose in the slot, it may be tightened by removing the tip assembly from the probe and peening the swege. The entire needle tip assembly may be removed from the probe head by turning it counterclockwise and unscrewing it. A spare needle tip assembly is supplied.

MODEL 314 ELECTRONIC VOLTMETER



REFERENCE LIST OF PARTS *

Resistors

Part #					
1	-	10,000,000 ohms,	Type CP-2,	1%,	Wilkor Products
2	-	2,500,000 ohms,	Type CP-1,	1%,	Wilkor Products
3	-	20,000 ohms,	Type EB,	5%,	Allen-Bradley Company
4	-	2,000,000 ohms,	Type CP-1,	1%,	Wilkor Products
5	-	20,400 ohms,	Type CP-½,	1%,	Wilkor Products
6	-	33 ohms,	Type EB,	5%,	Allen-Bradley Company
7	-	2,000 ohms,	Type CP-½,	1%,	Wilkor Products
8	-	6.8 ohms,	Type GB,	10%,	Allen-Bradley Company
9	-	200 ohms,	Type CP-½,	1%,	Wilkor Products
10	-	2,000,000 ohms,	Type CP-1,	1%,	Wilkor Products
11	-	1,000 ohms,	Type EB,	5%,	Allen-Bradley Company
12	-	47 ohms,	Type EB,	10%,	Allen-Bradley Company
13	-	30 ohms,	Type CP-½,	2%,	Wilkor Products
14	-	220 ohms,	Type EB,	5%,	Allen-Bradley Company
15	-	4,700 ohms,	Type CP-½,	2%,	Wilkor Products
16	-	10,000 ohms,	Type EB,	5%,	Allen-Bradley Company
17	-	330,000 ohms,	Type EB,	5%,	Allen-Bradley Company
18	-	4,700 ohms,	Type EB,	5%,	Allen-Bradley Company
19	-	3,000 ohms,	Type CP-½,	2%,	Wilkor Products
20	-	220 ohms,	Type EB,	5%,	Allen-Bradley Company
21	-	20,000 ohms,	Type EB,	5%,	Allen-Bradley Company
22	-	2,000,000 ohms,	Type EB,	5%,	Allen-Bradley Company
23	-	2,000 ohms,	Type EB,	5%,	Allen-Bradley Company
24	-	1,500 ohms,	Type CP-½,	2%,	Wilkor Products
25	-	220 ohms,	Type EB,	5%,	Allen-Bradley Company
26	-	33,000 ohms,	Type EB,	5%,	Allen-Bradley Company
27	-	1,000 ohms,	Type EB,	5%,	Allen-Bradley Company
28	-	1,000,000 ohms,	Type CP-1,	1%,	Wilkor Products
29	-	111,100 ohms,	Type CP-½,	1%,	Wilkor Products
30	-	56 ohms,	Type EB,	5%,	Allen-Bradley Company
31	-	220 ohms,	Type EB,	5%,	Allen-Bradley Company
32	-	3,500 ohms,	Type 5KT,	5%,	Sprague Electric Company
33	-	3,000 ohms,	Type CP-½,	2%,	Wilkor Products
34	-	33,000 ohms,	Type EB,	5%,	Allen-Bradley Company
35	-	7,500 ohms,	Type EB,	5%,	Allen-Bradley Company
36	-	2,000,000 ohms,	Type EB,	5%,	Allen-Bradley Company
37	-	3,000 ohms,	Type CP-½,	2%,	Wilkor Products
38	-	220 ohms,	Type EB,	5%,	Allen-Bradley Company
39	-	33,000 ohms,	Type EB,	5%,	Allen-Bradley Company
40	-	2,000,000 ohms,	Type EB,	5%,	Allen-Bradley Company
41	-	12,000 ohms,	Type EB,	5%,	Allen-Bradley Company
42	-	1,000 ohms,	Type EB,	5%,	Allen-Bradley Company
43	-	22,000 ohms,	Type EB,	5%,	Allen-Bradley Company
44	-	300 ohms,	Type EB,	5%,	Allen-Bradley Company
45	-	20 ohms,	Special,	1%,	Int. Res. Corp.
46	-	150 ohms,	Type EB,	5%,	Allen-Bradley Company
47	-	200 ohms,	Type ML-3 or	1%,	Mepco, Inc.
			Type 172-CU	1%,	Shallcross Mfg. Company
48	-	200 ohms,	Type 014EPA or	1%,	ITE Circuit Breaker Co.
			Type BX172	1%,	Shallcross Mfg. Company
49	-	500 ohms,	Type W-500, Potentiometer,		Int. Res. Corp.
50	-	540 ohms,	Type CP-½,	2%,	Wilkor Products
51	-	4,000 ohms,	Type 5KT,	5%,	Sprague Electric Company
52	-	1,250 ohms,	Type 5KT,	5%,	Sprague Electric Company
53	-	56 ohms,	Type EB,	5%,	Allen-Bradley Company
54	-	620 ohms,	Type EB,	5%,	Allen-Bradley Company